THE TROPHIC STATUS OF LAKE SIDNEY LANIER

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INTRODUCTION

Lake Sidney Lanier, located in northeastern Georgia, is a large reservoir in a watershed that is agricultural with urban and considerable suburban residential areas. Lake Lanier provides the drinking water for 60 percent of the population of Georgia and is also heavily used for recreation. Recreation, increasing urban and suburban development, and continued agriculture have resulted in siltation, sewage loading from treatment plants and septic tanks, and non-point source pollution. However, many of the effects that normally occur in heavily developed lakes, such as decreased transparency and blue-green algal blooms, have not been extensively noted in Lake Lanier. Data from a water quality monitoring program begun in 1987 are reported here and compared to data collected in 1978 and 1979 in order to evaluate the trophic status of Lake Lanier over the last 12 years.

METHODS

One hundred stations were established on Lake Lanier in 1987 and sampled yearly in August from 1987 to 1990. Thirty-four of these stations were sampled quarterly throughout the rest of this four year period. At each station temperature and dissolved oxygen (DO) profiles were taken at 1 m depth intervals with a YSI oxygen meter and chemical samples were collected at the surface, middle (thermocline), and 1 m above the bottom. Shallow stations were sampled only at the surface and bottom. Transparency was measured with a Secchi disc. These samples were analyzed for chlorophyll *a* using the fluorometric method (APHA, 1985). The lake was divided into five regions (see Table 1): (A) the Chattahoochee, (B) the Chestatee, (C) mixing zone of the two rivers, (D) lower lake (deep water stations) and (E) bays off the lower lake. The Carlson (1977) Trophic State Index was calculated from the chlorophyll *a* (TSIc = 9.81 ln Chl + 30.6) and the transparency

Table 1. Summary Table of Station Locations by Lake Regions, A through E. The one hundred stations of this study are compared to the Corps of Engineers study of 1978-79. Their stations are found in parentheses.

Lake Region	Stations In This Study (Corps)	Location on Lake
A	26 (2)	Chattahoochee
B	17 (3)	Chestatee
C	4 (2)	Mixing zone for the above rivers
D	31 (3)	Open lower lake
E	32 (4)	Bays off lower lake

(TSIt = 60 - 14.41 ln SD) for each lake region; the TSIc and TSIt for the whole lake were calculated using the average chlorophyll *a* and average transparency for all stations. The data collected in 1987-90 was compared to data collected at 14 stations for the Corps of Engineers in 1978 and 1979 (Envir. Sci., 1981). The TSIc and TSIt for the Corps stations was calculated using chlorophyll *a* and transparency values for the stations located in the five regions established in 1987. The areal hypolimnetic oxygen deficit was determined by the method described by Hutchinson (1957) and Wetzel (1970) for each of the five regions, using data collected in spring for overturn values for DO and the data collected in August for summer stratification values for DO.

RESULTS

A comparison of the TSIc and the TSIt by lake regions for 1978-79 and 1987-89 is shown in Table 2. The highest TSIc occurred in region A, the Chattahoochee, in 1987 and the lowest in region D, the open lake, in 1978. The highest TSIt occurred in region A in 1988 and the lowest in region C, the mixing zone, in 1989. The TSIt was consistently higher than the TSIc for all lake regions and all years. The TSIc for the whole lake increased over the 12 year peri-

Table 2. A Comparison of Trophic State Indices for Lake Lanier over a 12-year Period.

Lake Region	Chlorophyll a 1978	1979	1987	1988	1989
A	31.9	33.5	44.3	42.4	43.0
B	36.8	33.3	37.3	41.0	39.4
C	38.2	34.8	39.2	34.0	38.8
D	26.2	30.6	31.0	31.4	38.1
E	38.6	37.3	34.8	32.4	39.5
Whole Lake	35.1	34.4	38.3	37.5	40.2

Lake Region	Transparency 1978	1979	1987	1988	1989
A	49.1	53.8	52.9	54.5	49.3
B	48.6	51.4	54.0	50.6	46.8
C	42.0	45.4	48.4	45.7	41.3
D	42.4	43.9	44.2	43.8	43.9
E	49.0	52.2	48.3	49.2	45.5
Whole Lake	47.4	50.8	49.6	49.6	46.2

od. The TSIt varied somewhat but was always considerably higher than the TSIc.

The relative areal hypolimnetic oxygen deficit for the whole lake for the 13 year period from 1978 to 1990 is shown in Table 3. The deficits were higher in 1978 and 1979 than in 1987 to 1990. Much of this variation can be attributed to differences in sampling procedures (Table 1). In the earlier Corps study there were fewer stations, especially deep water stations, and the DO was collected only at 3m intervals.

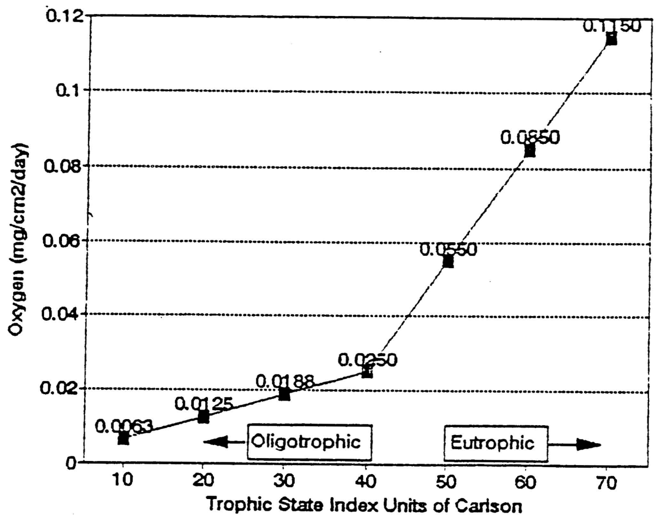
Table 3. Relative Areal Hypolimnetic Oxygen Deficit of Lake Lanier over a 13-year Period.

Relative Areal Hypolimnetic Oxygen Deficit (mg/cm2/day)					
1978	1979	1987	1988	1989	1990
0.069	0.093	0.053	0.049	0.055	0.048

DISCUSSION

Carlson's Trophic State Index has been used successfully to categorize a wide variety of lakes, and generally there is good agreement between Indices calculated using different parameters such as chlorophyll *a* and transparency: higher

Figure 1. Conversion Scale for Hypolimnetic Oxygen Deficit and the Trophic State Index of Carlson.

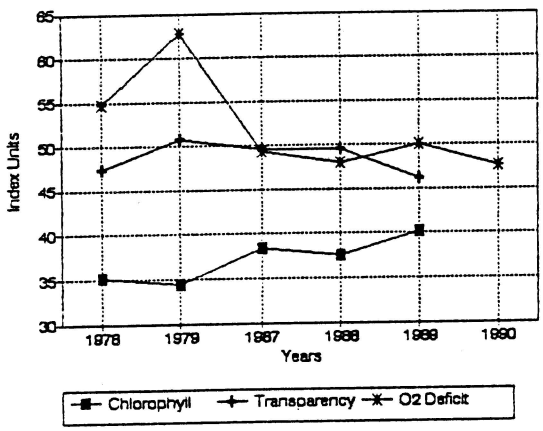


which decreases transparency. These TSIc and TSIt for Lake Lanier do not show this relationship, primarily because transparency in Lake Lanier is strongly affected by non-algal turbidity (siltation and wave action) and also because algal turbidity is unexpectedly very low. This discrepancy caused us to look at another trophic indicator, the hypolimnetic oxygen deficit.

In order to compare the hypolimnetic oxygen deficit to Carlson's TSI, a Trophic State Index was constructed for hypolimnetic areal deficit using the range of values suggested by Hutchinson and modified by Mortimer (Hutchinson, 1957). The scale is the same as the one used for Carlson's Index in which units of 10 indicate a doubling of algal biovolume. Values of 0.025 to 0.055 $mgO_2cm^{-2}day^{-1}$ mark the range of upper oligotrophy and lower eutrophy. These oxygen deficits were equated to Carlson's values of 40 and 50 respectively, and a linear scale in the eutrophic region was established using 0.015 units of oxygen deficit for each 5 units of TSI (Figure 1). The relative areal hypolimnetic deficit using this scale places Lake Lanier in the eutrophic range, results that show more agreeent with the TSIt than with the TSIc (Figure 2).

The interpretation we have made of these results is that the areal hypolimnetic oxygen deficit is the most accurate indicator for trophic state in Lake Lanier. The TSIt agrees fairly well with the oxygen deficit; however, transparency in Lake Lanier is often high because of non-algal turbidity. The TSIc appears to be artificially low. Consideration of the TSIc data alone places Lake Lanier in the upper oligotrophic or lower mesotrophic range, which is not borne out by other indicators.

Figure 2. Trophic State Indices for Whole Lake over a 13-year Period.



SUMMARY

Chlorophyll *a* should be a direct measure of in-lake productivity and therefore often the parameter measured. However, in Lake Lanier there is appears to be some process reducing algal productivity or removing algae from the water column so that the trophic status as measured by chlorophyll *a* is artificially low. Transparency is easily measured and often is a good indicator of productivity if there is not much non-algal turbidity. In lakes with high silt loadings, the TSIt is often rejected as a measure of lake status under the assumption that it does not reflect algal productivity. However, in Lake Lanier there is good agreement between TSIt and total lake metabolism as measured by hypolimnetic areal oxygen deficit. This deficit, which places the lake in the eutrophic range, appears to be the most accurate method for determining the trophic status of Lake Lanier.

Further research is needed to identify the cause of the low algal concentrations in the water column. There are indications that there may be an interaction between clays and algae in the water column which results in the adsorption and flocculation of algae and/or nutrients from the water column.

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